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Process of plant optimization through software development

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Abstract

Optimization of wastewater treatment plants is a global process. It can be done in many different ways yet all of them rely on a sound knowledge of the plant and the water treatment process in order to ensure effective optimization. One way of optimization is through the implementation of specialised software. No one can understand the complexity of the plant better than the employees themselves. Their work can become more effective with the help of the software which will put the data of the plant at their disposal and will already have incorporated know-how of the wastewater treatment process.

Keywords
automatic data analysis, data base, optimization, process control, software, teamwork

INTRODUCTION

Modern criterion for wastewater treatment is no longer based only on acceptable effluent parameters. Nowadays there is an increasing demand to treat water more effectively, with lower costs and primarily with a lower carbon footprint. Constant changes in external and internal conditions in the treatment plant make process control a complicated task. A dynamic control over treatment process is therefore needed. To maintain optimum process efficiency and reliability, it is necessary to compensate for disturbances by changing some of the process parameters. The challenge of process control is to determine how much change is required. Effective operational changes can usually be made to a process with little or no increase in cost. Analysis of plant operating data is the first step in facility evaluation and optimization (Tchobanoglous et al., 2003). In practice, analyses are usually done with a time delay, especially those which need more complex calculation. Immediate action is therefore postponed.

Employees at the Wastewater treatment plant Ljubljana have started to think ahead on the topic of wastewater treatment. In order to start a process of optimization, you have to know your plant well and you have to find the right answers to a number of questions. Being aware of the problems that the operating staff has to deal with on a daily basis, we set a goal three years ago to develop software which will centrally collect all kinds of data and thereby contribute to a transparent, reliable and economical operation of the plant.

We named the software e-Bak which in Slovenian stands for management of digital databases, documentation registration and communication. Our aim was to create user-friendly software which would be accessible on each computer that is in use. Before implementing the software we used several different data bases which were managed by different users. They were all running in Microsoft Excel which is not the appropriate software to use for daily handling of larger amounts of data. Plant operations were noted by

hand in a notebook, which was not the most effective method to clearly monitor what was happening in the plant. Before having the software it was difficult to coordinate people and to pass on instructions. At times this was also quite stressful and confusing. We tried to solve these problems through the new custom-made software based on the idea that data should only be entered into the system once.

METHODS

e-Bak is a client/server application that runs on a clients computer and makes requests to a remote server. The application is written in a high-level visual programming language (.NET C#) where user interfaces, forms and most business logic reside in the client application.

SQL Server Express Edition is a free product based on SQL Server 2005 technology, with maximum 4G database size. For bigger databases Microsoft® SQL Server is required. The database is automatically backed up on a weekly basis.

Clients and servers communicate over a computer network on separate hardware, but both client and server may reside in the same hardware system. All data is stored on the server which generally has a far greater level of security than most clients. Data storage is centralized, so updates to data are easy to administer. The application and SQL are running on a single physical server on two virtual machines. Virtualization was used because a single server can run multiple virtual machines, resulting in lower hardware costs and reduced power consumption, as well as enables you an easy disaster recovery.

RESULTS AND DISCUSSION

The basic idea was that each employee on the plant should be a software user. This avoids doubling the work but also means adapting the programme level to the different types of users. The first level is for operators. They do not require much information as they mainly input data, and are expected to be unskilled computer users. The second level is the level of superintendants, who review the data. They have access to the whole application except for the administration module. The highest level of user is the administrator, who can set up the software. Up until now we have launched five out of six modules (Figure 1). Each one targets a different problem that we wanted to resolve and can be run on its own on the basic platform.

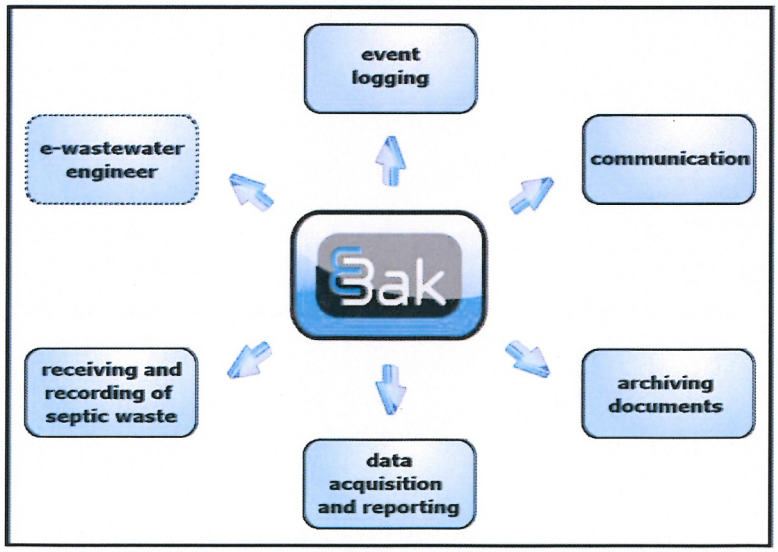

Figure 1. Different modules in the e-Bak software

One of the first modules was *event logging*. In this module we store a description of all events that are important for the operation of the plant. Events are stored chronologically and each has a unique number. All descriptions are attached to the exact device. In such a manner we can now monitor the history of each device we have. When an event is labelled with an activity of an "error" we have to abolish the error through further action. This way we can precisely follow how an error was dealt with. The operator can report each event to his superintendant who can decide how to solve the problem. The module is as integrated into our central control system (ABB Industrial IT 800xA) as the external software (third party application). In this respect, it is not necessary to run the software in order to add a new event into the log. If needed it is possible to print a report of events. By launching the module we have certainly reached a higher level of transparency and efficiency as well as simplifying teamwork, given that everyone can now examine the log from their own workstation.

The main aim of implementing the *communication* module was to improve mutual communication among employees. The effective operation of a wastewater treatment plant requires a high level of coordination amongst employees, especially if they work different shifts. For us this was a new way of informal communication in the shape of a dashboard and a forum. The dashboard represents one-way communication and is intended for exchange of quick instructions of short duration. The forum is more useful when we want to follow certain events, for debates on some activities or to carry out an internal training. This module was really beneficial for us. It encourages internal collaboration and is well accepted because of its simplicity.

We previously experienced problems with document registration. Documents like service reports, inspection reports, warranty lists, annual reports, etc. were always kept by the employee meaning it was often difficult for other employees to locate particular documents. We must admit that we have not paid particular attention to the development of the *archiving documents* module but we are now able to store digitalised documents in one place in the software. Due to the fact that each file can be attached to the suitable device in our tree structure of the plant, it is now much easier for everyone to find the document.

In the past operational parameters and procedures were usually chosen on an intuitive basis and upon anecdotal evidence. Nowadays instruments for the on-line measurements have become an integral part of the control systems used at treatment plants. A vast variety of instruments means that a wide range of information is collected. The operating staff is responsible for handling this information. Usually they perform a daily report on the most interesting parameters. One of our modules - *data acquisition and reporting* - is especially dedicated to the creation of daily operational reports with all kinds of desired parameters, alongside data preservation. In this module we can store and publish all kind of data - from on-line instruments and official laboratory analyses to data from the central control system, as well as data which are entered manually by our staff due to data specificities (brief remarks and settled volume of sludge for instance). As a matter of fact we wanted to centralise all the data gathered at the treatment plant. With the module we have simplified the whole process of data acquisition and we made it much more transparent and less time consuming. This was quite a hard task to accomplish but it was worth the effort because the next logical step will automatically lead our way to another module which we are going to name *e-wastewater engineer* (Figure 2) and which will represent the crown of the software.

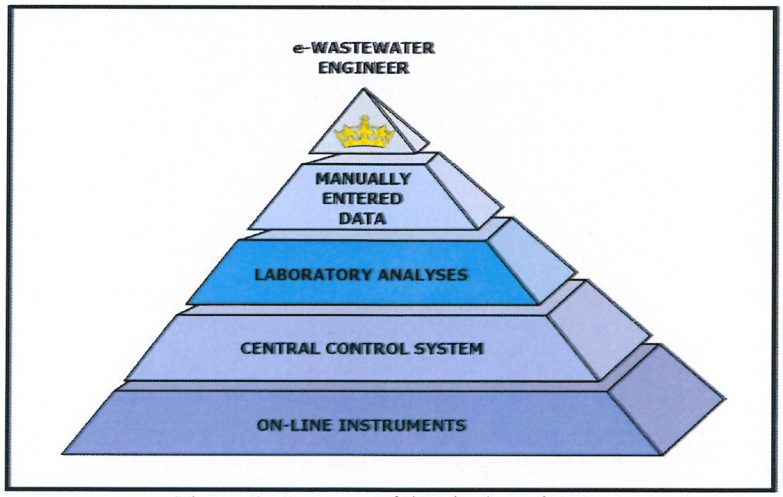

Figure 2. Structure of data in the software

The most important of all the created modules will be an e-wastewater engineer. We plan to finish this module in the following year and we are already looking forward to benefiting from the advantages it will bring. The e-wastewater engineer will be a module in which we are going to focus all of our understanding on wastewater treatment. Can you imagine that when you come to work you get an analysis report of the previous day in the shape you really want, where all the deviations are already pointed out? The only thing you have to do is to confirm or reject the results. This module will be based on all data from previous modules and on different analyses. By calculating different algorithms and efficiency index and by comparing different parameters, results and histograms on a daily basis, we will be able to act in time and therefore be more cost effective. We are also going to improve our measuring tools for inspection through using all kinds of verifications.

CONCLUSIONS

Implementing e-Bak has facilitated our operations. We now discuss the situation much more than we did before and we have alleviated ourselves of monotonous and time consuming data management and have focused on new improvements.

During the process of finalising the software, we will strengthen our understanding of wastewater treatment plant operations and certainly come up with new questions. Through these new experiences we will by all means start to think and operate in another way, which as a result will bring us to our primary goal - to enable the transparent, reliable and economical operation of our plant.

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